CHAPTER 4
DISCRIMINATION OF LAWN TENNIS TOURNAMENT

Lawn tennis tournaments have one distinct dominant play field color. This dominant play field color histogram has been used as the key to discriminate various lawn tennis video shots and described in detail in this chapter. We have presented a measure of shot importance based on lawn tennis rules and clustered only play field color shots as the important shots. Playfield color shot based sports video summary is potentially effective for browsing purposes because viewers will not miss any important events although they skip most of the break scenes. It is due to the fact that most highlights are contained within play scenes. Dominant colored frame of each play field color shot extracted as one of the key frame for creation of lawn tennis video summary. The experimental results carried out on the proposed scheme are promising.

The remainder of the chapter is organized as follows. Section 4.1 describes the Lawn tennis dominant color shot detection using color histogram, Section 4.2 provides shot importance measure based on lawn tennis rules, Section 4.3 presents lawn tennis tournament discrimination based on dominant color of the field. In Section 4.4 evaluated, presented and discussed the experimental results. Finally, conclusions are addressed in Section 4.5.

4.1 Lawn tennis dominant color shot detection using color histogram
In Lawn Tennis tournaments short play field color shots serve as localization of events like a faulty service, dead ball and fall a ball. While long shots indicate the players’ performance and points scored. Thus every short as well as long play field color shot are very important. Both the shots localizes important events as well as used to discriminate between the tennis tournaments. Play field color shot are measured by the mean values of each color component from color histogram of the all frames.

The lawn tennis tournament videos considered for experimentation of the effectiveness of the proposed algorithm are,
1) French open,
2) Wimbledon, and
3) US open.

Every lawn tennis tournament has one distinct dominant play field color (a tone of brown for French open tournament, a tone of green for Wimbledon tournament, and a tone of blue for US open tournament). The statistics of this dominant color in the HSV (hue-saturation-value) space has been considered. Hue values have been considered for computation of \( N \) number of color components. Amongst \( N \) color components red, green and blue color components computed by thresholding hue values. In color histogram analysis red color is treated as French Open playfield color, green color is treated as Wimbledon play field color, and blue color is treated as US Open playfield color.

Frame wise color histogram (3.1) gives the number of times a particular color has occurred in the frame. From these values mean value of red, green and blue color components of play field color shot can be defined as,

\[
H_R(k) = \frac{1}{N+1} \sum_{i=0}^{N-1} h_i
\]  

(4.1)

\[
H_G(k) = \frac{1}{N+1} \sum_{i=0}^{N-1} h_i
\]  

(4.2)

\[
H_B(K) = \frac{1}{N+1} \sum_{i=0}^{N-1} h_i
\]  

(4.3)

where,

- \( H_R(k) \) is mean value of red color components,
- \( H_G(k) \) is mean value of green color components,
- \( H_B(k) \) is mean value of blue color components,
- \( h_i \) is \( i \)th frame histogram, and
- \( N \) is number of frames in the play field shot.

The same framework can be applied for other lawn tennis tournaments like Australian Open, shanghai with minor adjustment in the parameter values such as thresholding of hue values. When the parameter values are changed
suddenly, the performance of proposed approach effects on precision and recall rate. Therefore, the parameters need to be refined iteratively and empirically to achieve the optimum performance results.

4.2 Shot importance measure based on lawn tennis rules
The shot importance is decided by considering the rules of International Real Tennis Professionals Associations (see APPENDIX I) and on viewers’ interest. All the time it is observed that viewers are interested in watching the events on the play field and least interested in the audience, display panels, close-up shots of faces, and advertisements. In Lawn Tennis tournaments short play field color shots serve as localization of events like a faulty service, dead ball and fall a ball. While long shots indicate the players’ performance and points scored. Consequently in our scheme short as well as long dominant colored play field shots are considered very important because with this

- Discrimination between various lawn tennis tournaments is achieved.
- These shots serve as accurate localization of events like faulty service, dead a ball, and fall a ball.
- It is possible to detect court lines as all play field color shot contains tennis court frames.
- Likely to detect and track the player and ball in the segment.
- These shots or segments also help professional tennis players and coaches to retrieve video segments in a meaningful manner.
- Furthermore play field color shots have been classified into two main classes that is Grass (green) Color Play Field Shots and Clay Color Play Field Shots.
- Moreover play field color shot are analyzed to extract three representative frames based on audio, visual and text features for video summarization.

4.3 Tennis tournament discrimination
Lawn tennis videos have been classified into relevant tournament class based on mean value of each color component of the shot. The segments of tournament of interest are play-field colored shots. Motivated by the dominant color of the field we classify play field color shot into three
tournament classes namely French Open tournament, Wimbledon tournament and US Open tournament. The distinctiveness of each tournament class has been described in the following Sub-sections.

4.3.1 French Open Tournament
The dominant frame color of this class of tournament is having a tone of brown. This brown color in histogram computation is considered as red color. Lawn tennis video is classified into this type of tournament class if mean value of red color component is greater than green and blue value i.e. $H_R(k) > H_G(k)$ and $H_R(k) > H_B(k)$.

4.3.2 Wimbledon Tournament
The dominant frame color of this class of tournament is having a tone of green, which is uniqueness of this type of tournament. Lawn tennis video is classified into this type of tournament class if mean value of green color component is greater than red and blue value i.e. $H_G(k) > H_R(k)$ and $H_G(k) > H_B(k)$.

4.3.3 US Open tournament
The dominant frame color of this class of tournament is having a tone of blue. Lawn tennis video is classified into this type of tournament class if mean value of blue color component is greater than red and green value i.e. $H_B(k) > H_R(k)$ and $H_B(k) > H_G(k)$. Discrimination of a shot into one of the said three tennis tournament classes has been computed by the mean value of dominant play field color value of the play field color shot.

4.4 Results and discussion
The sample results for lawn tennis tournaments considered are presented in this Section. The procedure of thresholding hue values for histogram computation, extraction of dominant colored key frame, and the variation of mean and standard deviation values is as discussed in Section 3.4. In this Chapter we have considered three lawn tennis tournaments and their respective dominant field colors are red, green and blue for analysis as
mentioned in Section 4.3. Figure 4.1 to Figure 4.3 shows the results of color histogram applied to Wimbledon shot w1, French open shot f2 and US open shot. The play field shot importance has been decided as discussed in Section 4.2 and accuracy of this is evaluated using parameters like recall rate and precision rate. Based on the lawn tennis rules and viewers interest in the tournament events, play field color shot are used for discrimination of various lawn tennis tournaments as shown in Figure 4.4.

The thresholding values i.e. parameters of the algorithms developed for features of the proposed framework are considered as defined in Section 3.3 and the evaluation of parameters recall rate and precision rate are computed. In most of the cases, when the parameters are changed, the performance such as precision and recall rate is affected.

For evaluation of the performance of play field color shot detections, we have used two parameters namely recall rate and precision rate. Recall rate (RR) is the percentage of obtained play field color shot by the algorithm with respect to the actual events (obtained playfield color shot + missed play field color shot) in the video (which is calculated as total of correct and missed detections). This indicator is important to show that an algorithm can detect most of the events while achieving as little misdetections as possible. Precision Rate (PR) is the percentage of obtained playfield color shot with respect to the overall events (obtained playfield color shot + false play field color shot) detected by the algorithm (which is indicated by the number of correct and false detections). This percentage can indicate the trade-off for achieving minimum misdetections. The equations for these parameters are,

$$RR = \frac{OPFCS}{OPFCS + MPFCS} \times 100$$ \hspace{1cm} (4.4)

$$PR = \frac{OPFCS}{OPFCS + FPFCS} \times 100$$ \hspace{1cm} (4.5)

where,

OPFCS is the obtained playfield color shot correctly detected,
MPFCS is the number of missed play field color shot, and FPFCS is the number of false play field color shot detections.

Table 4.1 Performance of play field color detections.

<table>
<thead>
<tr>
<th>Lawn Tennis Video</th>
<th>Total Shots</th>
<th>OPFCS</th>
<th>DPFCS</th>
<th>MPFCS</th>
<th>FPFCS</th>
<th>NPFCS</th>
<th>PR %</th>
<th>RR %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wimbledon 2009</td>
<td>97</td>
<td>35</td>
<td>52</td>
<td>17</td>
<td>07</td>
<td>61</td>
<td>83</td>
<td>67</td>
</tr>
<tr>
<td>French Open 2009</td>
<td>79</td>
<td>42</td>
<td>59</td>
<td>17</td>
<td>06</td>
<td>43</td>
<td>87</td>
<td>71</td>
</tr>
<tr>
<td>US open 2009</td>
<td>49</td>
<td>32</td>
<td>40</td>
<td>08</td>
<td>04</td>
<td>17</td>
<td>89</td>
<td>80</td>
</tr>
<tr>
<td>French Open 2010</td>
<td>08</td>
<td>04</td>
<td>06</td>
<td>02</td>
<td>01</td>
<td>05</td>
<td>80</td>
<td>66</td>
</tr>
<tr>
<td>Wimbledon 2010</td>
<td>27</td>
<td>15</td>
<td>24</td>
<td>09</td>
<td>04</td>
<td>12</td>
<td>79</td>
<td>62</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>84</td>
<td>70</td>
</tr>
</tbody>
</table>

The performance of play field color detections for Wimbledon, French open and US open lawn tennis tournament are as shown in Table 4.1. Our goal is to achieve an overall recall rate of 70% or greater while the lowest precision rate should not be less than 60%. Recall rate and precision rates measures the accuracy of the proposed algorithm. Based on the average statistics located at the last row of Table 4.1, it can be justified that the proposed play field color shot detection algorithm is sufficiently robust and reliable.
Figure 4.1 (a) to (f) Sample results play field color shot frames and their color histograms for Wimbledon shot w1.
Figure 4. 2 (a) to (f) Sample results play field color shot frames and their color histograms for French open shot f2.
Figure 4.3 (a) to (f) sample results play field color shot frames and their color histograms for US open shot.
The color histograms of Wimbledon, French open and US open tournament video shots are as illustrated in Figure 4.1 to Figure 4.3. These Figures shows the dominant play field colors of each frame in the shot. The algorithm estimates the mean values of each color component of the frames in the play field color shot. The mean of color values for red, green and blue color in every play field color shot is computed. Dominant color of the shot is evaluated and classified into relevant tournament class. Table 4.2 shows performance results of visual analysis of Lawn tennis video for discrimination of various tennis tournaments. The best graphical results of the algorithm for discrimination of lawn tennis tournaments are as shown in Figure 4.4.

Table 4.2 Performance of tennis tournament discrimination.

<table>
<thead>
<tr>
<th>Lawn Tennis Video</th>
<th>Format</th>
<th>Total Shots</th>
<th>Desired PFCS</th>
<th>Obtained PFCS</th>
<th>NPFCS</th>
<th>Dominant Color of PFCS</th>
<th>Tournament class</th>
</tr>
</thead>
<tbody>
<tr>
<td>Game1</td>
<td>AVI 320x240</td>
<td>97</td>
<td>52</td>
<td>42</td>
<td>61</td>
<td>Green</td>
<td>Wimbledon</td>
</tr>
<tr>
<td>Game2</td>
<td>AVI 320x240</td>
<td>79</td>
<td>59</td>
<td>47</td>
<td>43</td>
<td>Red (Brown)</td>
<td>French open</td>
</tr>
<tr>
<td>Game3</td>
<td>AVI 320x240</td>
<td>49</td>
<td>40</td>
<td>32</td>
<td>17</td>
<td>Blue</td>
<td>US Open</td>
</tr>
<tr>
<td>Game4</td>
<td>AVI 400x 226</td>
<td>08</td>
<td>06</td>
<td>03</td>
<td>05</td>
<td>Red (Brown)</td>
<td>French open</td>
</tr>
<tr>
<td>Game5</td>
<td>AVI 720 X 480</td>
<td>27</td>
<td>24</td>
<td>15</td>
<td>12</td>
<td>Green</td>
<td>Wimbledon</td>
</tr>
</tbody>
</table>
Figure 4.4 Discrimination of lawn tennis tournaments into Wimbledon, French Open and US Open.
4.5 Conclusions
The experimental results demonstrate that the proposed method of lawn tennis tournament discrimination is robust and effective for shot discrimination of various lawn tennis tournaments and extraction of dominant color frame as representative frame from the play field color shot for creating summary. The proposed approach discriminates between various lawn tennis tournaments.

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